WARREN BRIDGE
(Bridge No. 124)
R.I. State Route 114
Spanning the Palmer River
Warren
Bristol County
Rhode Island

HAER No. RI-40

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, P.A. 19106

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HISTORIC AMERICAN ENGINEERING RECORD

WARREN BRIDGE
(Bridge No. 124) HAER No. RI-40

Location:	R.I. State Route 114 Spanning the Palmer River Warren Bristol County, Rhode Island UTM: 19.309570.4622940 USGS Quadrangle: Bristol, Rhode Island, 1:25,000
Date of Construction:	1912-1916
Designer:	National Bridge Company Indianapolis, Indiana Daniel B. Luten, Chief Engineer
Supervising Engineer:	Clarence L. Hussey, Bridge Department, R.I. State Board of Public Roads (R.I. Department of Transportation)
Present Owner:	State of Rhode Island Department of Transportation Two Capital Hill - Rm 372 Providence, Rhode Island 02903
Present use:	Vehicular and pedestrian bridge
Significance:	The Warren Bridge is an early example of a reinforced concrete arch bridge. The bridge was designed by Daniel B. Luten's National Bridge Co. of Indianapolis, Indiana. It was determined eligible for listing in the National Register of Historic Places on January 10, 1989.
Project Information:	The Warren Bridge is structurally deficient due to deterioration of the arches and abutment walls and scouring of the bridge piers. The best short-term measure is the installation of a temporary bridge. This cannot be done without removing segments of the bridge's parapet rails. An approved MOA was ratified by the Advisory Council on Historic Preservation on September 15, 1994. The MOA includes a stipulation requiring HAER documentation. This report is to satisfy that stipulation.

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HISTORICAL BACKGROUND

The Crossing

The Warren Bridge spans the lower Palmer River approximately 3/4 of a mile north of the point where it feeds into the Warren River. This point has been the location of ferry and bridge crossings from Warren to Tyler Point since the late 17th century. As such, the crossing has provided passage between Newport and Providence, historic centers of Rhode Island commerce and government for three centuries.

In 1792, John Kelley, who had operated a ferry from Tyler Point to Warren, was granted a license from the R.I. General Assembly to erect a wooden drawbridge over the Palmer River at a location that had come to be known as Kelley's Ferry. The bridge was constructed by 1794. Passage of ships south from Mason Barney's important shipyard at Swansea (3 miles to the north on the Palmer River at Barneyville) necessitated the construction of a draw type bridge. Though plagued by shallow waters and strong tides, it was Barney's only means of transporting his ships to Narragansett Bay.

Kelley's Bridge on the Palmer River was located at the southern terminus of a highway running northerly to Swansea and west to Providence. It provided passage between Boston, Providence and Newport. In order to serve the growing settlement of Barrington, a company was formed in 1802 with the initial intention to erect a toll bridge connecting Warren, Little Island, Tyler Point, and Old Ferry Lane in Barrington at a point south of the present Barrington and Warren Bridges. The company also planned to build "a great public road from Warren to Providence in the most direct route."[1] With the proposed toll on the new bridge system equal to the toll exacted at his single crossing, Kelley, recognizing the effect the new bridge system would have on his business, sought an agreement with the newly-formed Warren and Barrington Bridge company. In this agreement Kelley would continue to operate his toll bridge and the Barrington company would erect a new bridge from central Barrington to Tyler Point--a successful and mutually beneficial arrangement. From there, passage could be made over Kelley's Bridge to Warren. An agreement was reached in May of 1802 between Kelley and what was now called the Barrington Toll Bridge Company. Tolls were collected at each crossing.

A gale in September of 1815 washed out both bridges and new construction was begun in October of the same year. By 1831 Captain James Bowen had acquired controlling interest in the Barrington Toll Bridge Company. He made an agreement with the heirs of Kelley to collect one toll for both bridges and divide the proceeds equally. This arrangement continued until 1872 when the State of Rhode Island purchased the two bridges for $6,000 and eliminated all tolls. In the agreement the towns of Barrington, Warren, and Bristol were to maintain the bridges jointly.

In the mid-19th century, John Kelley, a descendant of the original ferryman, took advantage of the strong and rapidly moving tidal waters on the Palmer River and erected a tide mill on the south side of the bridge. The 1850 Barrington census describes a grist mill valued at $4,000 and a yield of 7,000 bushels of milled corn and rye.[2] During this period, Kelley had a single span pony bowstring arch truss bridge erected over the Palmer River. This type of bridge, patented in 1840 by Squire Whipple, was in use until the late 19th century for spans between 70 and 175 feet long.[3]

By 1889, the Town of Warren replaced the bowstring arch bridge with a wrought iron truss swing bridge over the Palmer River at a cost of $27,000. This bridge, which retained the name of Kelley's Bridge, was of the Pratt type, used for spans of from 30' to 150' long. Despite the fact that Barney's shipyard had long since closed and that a movable bridge was unnecessarily expensive, Warren town officials had little choice in the matter. Residents of the hamlet of Barneyville to the north had long enjoyed the Palmer River's U.S. War Department status as a "navigable stream." Warren could in no way obstruct boat passage with a fixed bridge. The decision to erect a swing type of bridge over the Palmer River was born of a threat from upstream.

Although Barneyville had ceased to be a major shipbuilder by the time of the Civil War, it maintained rights in perpetuity to an unobstructed passage to the Warren River and Narragansett Bay. Barneyville made this view known to Warren town officials. This despite the fact that development had long depleted the forests needed for lumber and that navigation on the shallow river--harrowing even in Barney's day--was near impossible for all but small boats. Faced with the prospect of a boat demanding passage, Warren erected a wrought iron drawbridge--with a draw that was barely used, a so-called "drawless drawbridge."[4]

Both the Warren and Barrington Bridges had deteriorated to a dangerous degree by the first decade of the century. A February 1910 *Providence Journal* article described the condition of the Bridge over the Palmer River:

> Kelley's Bridge has a fixed place in mind of travellers because it is the point where they must alight and walk the length of the structure--and a mighty bleak place for a winter walk it is, too. The condition of the structure has

> been such that for four years past it has not been deemed safe to operate street cars across it. It is said to be 17 years since the draw has been swung and should a vessel owner now demand passage, as entitled to by law, it is figured that it would require a small fortune to cut the planks, cables, pipes, etc. and make the other changes necessary to open the bridge.[5]

In January of 1912, the three-member Bristol County Bridge Commission submitted a report to the Rhode Island General Assembly. A year earlier the Assembly had established the Commission to inquire into the "advisability and necessity of the State assuming control of the bridges and approaches thereto, in the towns of Barrington and Warren..."[6] Town-sponsored engineering reports on both the Warren and Barrington Bridges had already indicated that neither the bridges nor the 550 foot causeway on the Barrington side were safe for vehicular traffic. After conducting its own investigation, the Commission concurred with the local studies.

The Commission found Kelley's Bridge unworthy of any more expenditure for repairs. It had been closed to trolley traffic and would soon be closed to vehicular traffic as well. However, the east and west approaches to Kelley's Bridge were judged to be in good condition and of sufficient integrity to serve a modern bridge.

An interesting component of the Commission's study was a traffic survey conducted to determine the importance of the bridges to Barrington, Warren and the State. For seven consecutive days, between 6:00 AM and 12 PM in September of 1911, investigators kept a record of the number and types of vehicles, as well as the number of pedestrians crossing the bridges. The following are the results of the survey:

1,663	One-horse vehicles
364	Two-horse teams
4	Teams of more than two horses
929	Bicycles
2,554	R.I. automobiles (outside of Barrington and Warren)
256	Local automobiles
853	Automobiles (outside of R.I.)
4,316	Car passengers
5,950	Pedestrians
16,889	Total of pedestrians and vehicles

The Commission report left little doubt as to the condition and safety of the bridges and causeways. In the words of the

Commission:

> The entire situation of both bridges and the causeway does not apparently warrant the amount of money necessary for repairing structures of their character. It therefore appears that new bridges and a rebuilt causeway are imperative.[7]

Test borings, carried out as part of the study, were made along the bottoms of the Palmer and Barrington Rivers where future bridge footings would lay. These were found to indicate "rock formation of a solid and substantial nature within easy reach of the surface." In conclusion, the Committee sought estimates from three local contractors for two "modern reinforced concrete bridges,--one of two spans to take the place of the present Kelley's Bridge,--and one of three spans to take the place of the present Barrington Bridge."[8] As both bridges were located over tidal waters, it was required that plans be submitted to the State Harbor Commission and the National War Department. The Harbor Commission subsequently approved the proposal and the War Department released Warren from the requirement of replacing Kelley's Bridge with another drawbridge, provided that the new structure had an 8 foot clearance over mean high water.

<u>The Move to Concrete Arch Construction</u>

The detailed specifications furnished to the cost-estimating contractors and the General Assembly, however, varied considerably from the actual design of the Warren and Barrington Bridges. The Commission specified concrete beam bridges, not arch bridges. This specification was made despite Barrington Town Council President E.L. Spencer's observation that boat owners at the nearby Barrington Yacht Club spoke favorably of a "longer and wider span than the present one, with a series of arches of concrete."[9] Barrington's boat owners were in good company--the newly-constituted Bridge Department, a division within the R.I. State Board of Public Roads,[10] advocated concrete arch construction for spans between 5' and 75' long.[11] In fact, this choice was representative of a general trend on the part of the nation's state highway departments.

The reasons for the change from Commission design recommendations to the design actually constructed can probably be traced to a visit paid to the State Board of Public Roads at their weekly meeting of May 1, 1912. At this meeting, Walter N. Denman, a Springfield, Massachusetts representative of the National Bridge Company, Indianapolis, Indiana, bore a letter of introduction from R.I. Governor Aram Pothier. He made a presentation to the Board on the benefits of reinforced concrete arch bridges--as designed by Daniel B. Luten, chief engineer and founder of the company. By this time Luten held a number of patents on various aspects of concrete bridge design. He was a great promoter of reinforced concrete arch bridges and a great believer in their beauty, economy, and utility.

At the 1912 annual conference of the National Association of Cement Users Luten spoke of his work:

> A concrete arch, in harmony with its surroundings, but without ornamentation or embellishment of any kind, is an exceedingly beautiful structure. A concrete girder under similar conditions may be an exceedingly ugly structure. Why is it that the concrete girder bridge presents so undesirable an appearance, while the arch bridge is such a handsome improvement? Not alone because of the natural beauty of the surroundings; not merely because of the white-concrete in the arch view. The concrete arch presents the more pleasing appearance because it employs concrete in a thoroughly natural manner.[12]

Luten was not alone in his assessment of arches and girders. Frank P. McKibben of Lehigh University, writing in *Concrete-Cement Age* later that same year, viewed concrete arch bridges not only in terms of their structural qualities but as manifestations of civic pride: "The arch is a beautiful form of construction, and the ease with which concrete can be molded into graceful curves appeals alike to engineers and the general public." On a note more likely to pique the interest of elected officials, he added:

> ...the labor and most of the materials can be furnished locally. In most cases the sand, the stone and the labor can be secured without going beyond the local supplies. Only the cement and the steel need be brought in, and in not a few places these may also be obtained within a short distance of the bridge site. Here, then, the structure becomes largely the product of home talent, and correspondingly greater is the feeling of pride and interest in it.[13]

Denman approached the Board at a time when the new Bridge Department of the State Board of Public Roads had completed a survey of R.I.'s highway bridges. The survey was conducted under the supervision of Clarence L. Hussey, Chief of the Bridge Department and Rhode Island's first State Bridge Engineer. In the State's existing bridge inventory the Department "found almost every design of bridge construction imaginable except those of the latest design, some of them in an absolutely unsafe condition and some others fast approaching a similar condition." The Board decided to adopt "a standard form of construction patterned after the most modern and improved designs for reinforced concrete construction..."[14] This high regard for concrete was well-founded: the State's first reinforced concrete bridge, the 75' Flat River Bridge (RIDOT No. 71)[15] in Coventry, had served Rhode Island without any maintenance since its construction five years earlier in 1907.[16]

Denman's presentation was a success. The State Board of Public Roads made an arrangement with his company to use the "Luten system of reinforced concrete bridges." In return for a 10% compensation for the use of the Luten patents,[17] the National Bridge Company would "draft and submit plans or designs for such bridges as might be called for, and to furnish the services of D.B. Luten and Walter Denman as consulting engineers whenever required." Specifically, Denman was asked to return with plans for the Warren and Barrington Bridges.

Although the original Luten plans are no longer extant, State Board of Public Roads records indicate they were submitted on June 6, 1912. The final plans approved by Clarence Hussey, incorporate Luten designs and some modifications by Hussey. The Board promptly placed advertisements seeking construction bids on the Warren and Barrington Bridges. The Warren Bridge contract was awarded to E.J. Doyle and Co. of Albany, New York at a cost of $29,600; completion of the work promised in 120 days. The construction company of Miller and Mullen (Boston) bid successfully on the Barrington Bridge, but their bid on the Warren Bridge exceeded that of Doyle and Co. by more than $12,000 and their completion date by 90 days. The contract was awarded to Doyle on July 1, 1912.

Final specifications for Warren called for a temporary wooden bridge to be constructed to the north of the existing bridge, and a reinforced concrete bridge of three arches with causeways and approaches--a total of 500 feet overall. Work began immediately.

Early in the construction of the temporary bridges it became apparent to the State Board of Public Roads Supervising Engineer, Clarence L. Hussey, that E.J. Doyle and Company was in trouble. The 1913 Annual Report gave the following description of work on the Warren Bridge:

> The contractor at no time placed an adequate equipment of machinery upon the job to insure the timely and proper completion of the work. He also attempted to do work contrary to the specifications and the direction of our supervising engineer, and so delayed the progress of construction that at the expiration of the time limit for its completion not more than ten per cent of the work had been done. The temporary bridge which had been built for the

> accommodation of travel became unsafe and had to be closed; this he refused to rebuild, and practically abandoned all work on the contract.[18]

A lengthy legal conflict ensued that was to involve the Board, Doyle, local lawyers, consulting engineers and Rhode Island Attorney General Rice. By November, Doyle had removed all of his equipment and workmen. The State Board of Public Roads succinctly noted that he was "utterly incompetent in an undertaking of this kind."[19] On December 7, 1912 the Warren Bridge contract was relet to Miller and Mullen, whose construction to date on the Barrington Bridge had been described as "workmanlike and satisfactory."[20]

By the winter of 1913-14 the bridge was still only in partial use--lacking sidewalks, wire conduits, manholes, and a permanent roadway. It was not the common practice of early 20th century bridge builders to contract for finish work--and this often included the road surface. The earth fill for the area over the arches required a year's time to settle; only temporary road surfaces could be applied until that time. After a year, another contractor would finish the job.

Despite these construction difficulties, the 1913 Annual Report of the Board of Public Roads looked back upon the 18 months of construction of the Warren and Barrington Bridges with evident pride:

> Built mainly with by Rhode Island labor, with every precaution for public safety and convenience, of acknowledged excellence of material and workmanship, with symmetrical lines, true camber, and smooth white finish, these structures are a source of pride and satisfaction to the Board and credit to the State.[21]

In December 1913 the Board applied a cinder road surface--a satisfactory solution until the heavy traffic of the summer of 1914 ground it "into fine black powder, making a very objectionable condition." The only solution to the problem was "frequent and generous watering."[22] In the summer of 1915 the bridge roadways were given a gravel surface. A special State appropriation permitted the application of a bituminous macadam surface to the roadway in 1917. A distinctive feature of the new bridge was the urn-shaped, pre-cast concrete balustrade designed by Clarence Hussey. Hussey, whose office was in the basement of the recently-completed R.I. State House (designed by McKim, Mead and White), modeled the urns after those found on that building.

By 1929 vandalism and auto accidents had taken their toll on the concrete urn balustrade of both the Warren and Barrington

Bridges. The Warren bridge was particularly affected because of its curved approaches. The same year, the State Board of Public Roads replaced the open balustrade of the Warren Bridge with the current solid concrete parapet wall. Balustrade sections salvaged during demolition on this project were used to repair broken sections on the adjacent Barrington Bridge. This experience with the easily-damaged urn balustrade prompted a shift in the Bridge Department's design policies to the solid parapet wall evident in surviving concrete bridges of the period.[23]

The 1938 Hurricane provided a major test of the durability of Rhode Island's concrete arch highway bridges. Both metal railroad trestles to the north were completely washed out in the storm. The January 1939 Annual Report of the Department of Public Works gave the following assessment:

> Although a tremendous volume of water passed through the bridge openings and over the approaches of the Warren and Barrington Bridges, apparently little damage was done to the channels or foundations. There was some evidence of scour and in a few places additional rip-rap will be necessary to protect the footings of piers and abutments.[24]

A further assessment in 1939 was not so optimistic. Streambed erosion was worse than previously observed. Eventually over 600 tons of rock and gravel were placed in the tidal waters to prevent further erosion.

Periodic attempts have been made to repair and reinforce the concrete piers below and at the waterline (1925, 1939, 1966 and 1993). These repairs included the placement of steel plates and beams (tremies) to shield them from tidal erosion as well as the placing of stones and concrete tetrahedrons to serve as rip-rapping around the piers. Recent analysis from test borings shows that this pattern of pier and footing damage may have resulted from faulty construction methods in 1912-13, the concrete being too thin to maintain the stone aggregate in suspension. In this condition, the aggregate would settle to the bottom during the concrete pour, leaving the pier structurally weakened and susceptible to undermining and erosion.

The trolley tracks in the center of the original bridge roadway were removed ca. 1948 when Rhode Island streetcar service was abandoned. The original tapered concrete lamp posts with glass globe and bronze bracket were replaced (ca. 1960) with the present style of aluminum posts and mercury vapor lamps.

SIGNIFICANCE

Concrete Bridge Construction

The use of concrete as a construction material dates to the Hellenistic period when Greek engineers used it in the building of aqueducts. Concrete's first wide use is, however, associated with the Romans, who combined locally available volcanic sands with lime and aggregate. This combination provided a durable material, often used in combination with masonry or brickwork, that survives to the present in surprisingly good condition. The Romans used concrete as a masonry substitute, a material strong in compression but weak in tension.

Concrete fell into disuse during the Middle Ages and was not reintroduced until the mid 18th century. In the early 19th century Joseph Aspdin produced "Portland" cement by the careful measurement and mixing of limestone and clay. The resulting stone-like cement bore a resemblance to the Portland building stone commonly used in England, hence the name. While this new material, mixed with aggregate, was superior to its ancient counterpart, it was not until the introduction of steel reinforcement in the late 19th century that concrete came to be used as a material with strength in tension and compression, applicable to modern arch bridges.

In 1889, Ernest Ransome built the first reinforced concrete arch bridge in San Francisco's Golden Gate Park. Although this bridge represented a significant advance in bridge construction, its conservative design and surface treatment suggested the masonry types that preceded it. By the turn of the century, a new generation of bridge designers would begin to grasp the structural potential of reinforced concrete and begin to design to those possibilities. Daniel B. Luten, a great promoter and popularizer of reinforced concrete bridges, was notable among this early generation of concrete bridge designers and contractors.

Daniel B. Luten

Luten had studied civil engineering at the University of Michigan, where he received his B.S. in 1894. After graduation he served for one year as assistant to Professor Charles E. Greene, a leading authority on the elastic theory of arch analysis and author of *Greene's Graphic Method of Truss and Arch Analysis.* Luten spent the next four years at Purdue University, where he taught courses in architectural engineering. He resigned his position in 1900 to practice engineering. After a year working on roads and pavements, Luten moved exclusively into bridge design and construction. He remained a designer/contractor until 1906 when he limited his practice to design and supervision. During these early years Luten patented many designs and improvements in concrete bridge construction, his influence extending beyond the home base of Indiana through active promotion, including elaborate brochures, stereopticon lectures and extensive writing for professional journals and conferences.

Soon Luten's representatives were pitching bridges of "Luten design" to states and municipalities across much of the United States. According to a 1924 promotional booklet, *Reinforced Concrete Bridges*, Luten had "supervised the design of approximately 20,000 concrete bridges, of which over 13,000 have been erected of spans from five to 192.5 feet each." In the same booklet Luten provided a list of 30 advantages of concrete bridges. Among the more practical advantages:

> Concrete bridges are permanent improvements.
> A concrete bridge is the only bridge that grows stronger as it grows older, thus providing for increased weight in traffic.
> The concrete arch will discharge more flood water for a given flood level than other forms of opening of the same area.
> Concrete bridges are flood-proof, frost-proof, rust-proof, and fire-proof.

And among the aesthetic advantages:

> Concrete arch bridges have copings and roadway cambered in graceful vertical parabolic curves.
> Concrete arch bridges have beauty of curve and line secured by proper proportions.
> Concrete arch bridges have their arch rings whitened by polishing and, their walls softened by bush-hammering.[25]

Essential to Luten's work was the protection afforded him by U.S. patents. He was an impassioned advocate of patent protection as well as the benefits such protection brought to the engineering community and to communities in general. He would often use the forum of professional conferences to discuss his patents and the broader subject of patent protection. Luten was also willing to defend his patents in court when he received reports of contractors infringing upon what he believed to be proprietary designs. He was not always successful in this litigation; in one important case in 1915 six of his patents were declared void by a judge who saw them as "the mere exercise of mechanical skill" rather than ground breaking knowledge.[26]

Although Luten's designs were many and varied there are certain features common to them. Notable among them was the tendency to lighten bridge piers for a more flowing appearance. His substantial background in arch stress analysis allowed him to counteract the horizontal thrust of one arch with its adjacent arch--thus minimizing the mass of the arch piers. He also insisted, in multiple span arch bridges, that the center arch be slightly larger to offset the visual effect of foreshortening that made the middle span appear smaller. Both of these features are visible in the Barrington and Warren Bridges. To Daniel Luten, engineering was "the art of applying science and the science of employing art."[27] He believed, as did many artists and designers of the early modern period, that structures should reveal their design elements and demonstrate honest use of materials. Daniel Luten disdained non-functional ornament and celebrated simple engineering structures "in harmony with their surroundings."[28] In this sense he contributed to the popularization of these essential modernist ideas in the American built environment.

Clarence L. Hussey

Relocating to Providence after his graduation from Massachusetts Institute of Technology in 1908, Clarence L. Hussey worked in various capacities in the engineering field before joining the R.I. State Board of Public Roads in 1912. The Board had recently established a Bridge Department to oversee the design, construction, and maintenance of the State's highway bridges. Hussey was hired as Chief Bridge Engineer. His first major project was to supervise the construction of the Barrington and Warren Bridges. In this capacity, he carefully documented all phases of their construction with photographs and hand-written notations.[29] Hussey had a profound influence on bridge design and construction throughout the state between 1912 and 1925.

An expert in the relatively new field of reinforced concrete construction and a nationally-recognized bridge engineer, Hussey formulated new, stronger concrete mixes and applied this knowledge to innovative and cost-saving bridge designs. One of the most notable of these innovations was the modified arch bridge, a design that saved as much as 50% of the concrete normally required for a span of comparable size. The modified arch had inclined, rather than vertical, spandrel walls and sidewalks and railings that were carried on brackets anchored to the arch ring. In the words of an American Society of Civil Engineers remembrance of Hussey published after his death in 1925, "His ideas, although marked by striking originality, had the saving virtue of reasonableness."[30] Hussey designed the Washington Bridge between Providence and East Providence, the original span of which still carries westbound traffic over the

Seekonk River. He also designed the only concrete through arch bridge in Rhode Island. Completed in the last year of his life, it spans Wickford Cove and is appropriately named the Clarence L. Hussey Memorial Bridge.

DESCRIPTION

The Warren Bridge is a three-span, reinforced concrete structure with filled spandrel walls. Three elliptical arches allow the Palmer River to pass below the roadway. An 81' concrete extension wall serves as the west approach, terminating at the west abutment. At the northwest corner of the extension wall an additional 58' extension curves onto Sowams Road. A 210' curved extension and 89' causeway serve as the east approach.

The bridge is 228' long overall, with span lengths of 62', 67', and 62'. This scheme of varying arch lengths follows designer Luten's insistence that the center arch be the largest to compensate for the optical distortion that would make it appear smaller. A cadence of gradually increasing and decreasing arch spans gives the illusion that all arches are of the same length.

The 30' wide roadway is bound by concrete sidewalks and parapet walls on both the north and south sides of the span; these add another 13' of width to the span for an overall width of 43'. The center of the bridge at the highest point of the deck is 11.25' above mean high water. The deck elevation at the abutments is 10' above mean high water. The roadway surface is paved with asphalt and has been resurfaced several times since the bridge's construction between 1912 and 1917. Although the concrete bed designed to carry streetcar tracks remains under the asphalt, the tracks that once ran down the center of the bridge have been removed--probably ca. 1948, the final year of R.I. streetcar service.

The original open concrete balustrade walls were replaced with the present recessed-paneled concrete parapet walls in 1929. The panel pattern matches that found in the causeway walls of the original construction. Though lacking any surface ornamentation, the surfaces of the bridge are adorned with two types of concrete finishes. The spandrel walls and the recessed panels are "bush-hammered," a rough finish that reveals much of the aggregate stone. The arch ring and raised portions of the parapet walls were originally rubbed or "polished" to a smooth concrete finish with little aggregate evident. Though still visible, these distinctions in surface treatment are subtle due to years of exposure to weather.

Six modern, aluminum lamp-posts are now mounted atop the south parapet wall of the bridge and causeway, replacing the original tapered concrete posts. One lamp post is placed on the curve of the northeast extension wall. The original poles (rising more than 17' above the roadway) carried bronze brackets with light fixtures. Although original plans called for a separate trolley span wire and supports, the span wires were incorporated into the light posts at the time of installation in 1916. These posts, as well as their solid concrete bases, were placed at intervals that mirrored the arch piers and abutments of the substructure on both the north and south railings. These original concrete lamp posts and bases were left unchanged during the 1929 replacement of the balustrade railing. The current aluminum lamp posts, similar to those installed in 1960, are mounted on stepped concrete pedestals that rise above the cap of the parapet wall.

Typical of bridges of the period, the span's piers demonstrate the move toward construction with reduced massing. By balancing the horizontal thrust of adjacent arches, the Luten design minimized the horizontal strain placed on the piers. This engineering scheme paired with the great strength of reinforced concrete permitted the design of piers considerably thinner than their masonry counterparts--only 4.5' thick at the arch spring lines. Similarly, the arch barrels themselves are relatively thin, especially when one considers that they are the key structural elements carrying the weight of the roadway. In order to maintain desired aesthetic characteristics, these thicknesses are neither uniform between the arches nor uniform along the length of any one arch, varying from 16" thick at the crown of the end arches to 17" thick at the crown of the center arch. These arch barrels flair to 27" and 26" respectively as they reach the abutments and piers.

Although much stronger, cheaper, and more workable than stone, concrete had one significant disadvantage in bridge construction. It was much more susceptible than stone to wear from the scouring action of moving water--certainly an issue here in the swift current of the Palmer River. In order to counteract this problem, the design called for a protective layer of 11" granite ashlar on surfaces affected by tidewater. This was a standard State Board of Public Roads practice, applied to structures exposed to tidewater as well as mill stream pollution.[31] On the Warren Bridge, three to four courses of granite were placed on the lower portions of the causeways. The piers, which were situated in deeper sections of the river had as many as nine courses of stone.

Additional attempts to reduce the effects of water action on the piers are visible on the bridge today. Steel fenders have been placed around the northern and southern sides of the protruding cutwaters of the eastern pier of the bridge. Such fenders reduce damage to the piers by tidal action and protect them from collision damage from boat traffic, flotsam, or ice. Damage to the unprotected western pier is evident on its south side where some stones have fallen.

There are a few distinctive features of this span. The curve of the eastern approach supports archival evidence indicating that the bridge follows the path of an old crossing. Had this been a new crossing, alignments would have likely been established to eliminate this curved approach. Construction plans for the bridge indicate the need to remove stone walls which served as the approach to the preceding span. A low, stone rubble wall along the northern side of the eastern approach may be a remnant of construction from the older bridge. A small wing wall runs approximately 10' north-east from the eastern abutment then east 40', parallel to the approach. Although similar to the wing walls of many spans of Luten design, this type of asymmetrical wall is unique to the northeast corner. This wall is not indicated on any extant plans for the bridge. Perhaps it was constructed instead of a 41' long "retaining wall" shown to run north from where the eastern abutment reaches the water on the original plans. This wall may also have been built after initial bridge construction to shield the causeway from tidal action. The northwest and southwest corners of the bridge extension wall are marked by U.S. Geological Survey benchmarks. Located on the upper surface of the wall, the markers are dated 1956. The southwest extension wall end post also carries the inset bridge number.

SOURCES OF INFORMATION/BIBLIOGRAPHY

Engineering Drawings

Original construction and alteration/repair drawings for Bridge No. 124 are on file at the Rhode Island Department of Transportation, 2 Capital Hill, Providence, Rhode Island.

Historic Views

A comprehensive collection of black and white photographs (approximately 5.5" x 3.25" format) documenting the construction and repairs of Bridge No. 124 are also on file at the R.I. Department of Transportation. The corresponding negatives are on file at the Rhode Island State Archives, Westminster Mall, Providence, R.I.

The Massasoit Historical Association, Warren, R.I., has a collection of continuous tone photographs, halftones and graphics depicting the crossings of the Palmer River dating from the period of Kelley's rainbow truss bridge (ca. 1880).

The Barrington Preservation Society, housed in the Barrington

Public Library, has a collection of continuous tone photographs and halftones depicting the crossings of the Palmer River dating from the same period.

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NOTES

1. As quoted in Thomas W. Bicknell, *A History of Barrington* (Providence: Snow and Farnham, 1898), p. 458

2. From 1850 Barrington Census, as quoted in Nicholas Gizzarelli, *Barrington Roads* (unpublished manuscript on file at Barrington Preservation Society)

3. T. Allan Comp, *Bridge Truss Types: A Guide to Dating and Identifying,* Technical Leaflet 95 (Nashville: American Association for State and Local History, 1977), p. 8

4. "The Battle of the Drawless Draws," *Providence Sunday Journal,* 6 March 1910, Sec. 4, p. 1

5. "Bill Would Close Channel at Warren," *Providence Daily Journal,* 27 February 1910, p.2

6. Resolution from January 1911 session of the Rhode Island General Assembly, as quoted in the "Report of the Bristol County Bridge Commission" (Providence: State of Rhode Island, 1912), p.1

7. ibid p. 4

8. ibid p. 7

9. "To Repair Barrington Bridge," *Providence Daily Journal,* 24 January 1912, p.2

10. This agency, established in 1902, was responsible for the improvement and maintenance of the State's highways and bridges.

11. *12th Annual Report of the Rhode Island State Board of Public Roads* (January 1914), p. 32

12. Daniel B. Luten, "Concrete Bridges." *Proceedings of the National Association of Cement Users,* 8th Annual Convention, Vol. 8, No. 12, 1912, p. 631

13. Frank McKibben, "The Present Status of Bridge Building." *Concrete-Cement Age*, Vol 1, No. 6 (December 1912), p. 48-49

14. *11th Annual Report of the Rhode Island State Board of Public Roads* (January 1913), p. 29-30

15. This bridge was replaced circa 1955 by the current bridge.

16. "A New Era in Bridges." *The Providence Sunday Journal*. 22 February 1914. Sec. 5, p.5

17. Per minutes of the State Board of Public Roads meeting of August 12, 1912, compensation for use of the Luten patents was increased by another 10% (manuscript Records of the State Board of Public Roads, on file at the Rhode Island State Archives) to include patents, engineering and inspection (*11th Annual Report of the Rhode Island State Board of Public Roads*, p. 34).

18. *11th Annual Report of the Rhode Island State Board of Public Roads* (January 1913), p.32

19. Manuscript Records of the State Board of Public Roads, minutes for meeting of Nov. 8, 1912 (page 333)

20. *11th Annual Report of the Rhode Island State Board of Public Roads* (January 1913), p. 31

21. *12th Annual Report of the Rhode Island State Board of Public Roads* (January 1914), p. 39

22. *14th Annual Report of the Rhode Island State Board of Public Roads* (January 1916), p. 49-50

23. It is possible that the bush-hammered, recessed panel concrete parapet wall is a Clarence Hussey design. This type of wall was used until 1950 when the R.I. Department of Transportation began to use steel bar railings.

24. *4th Annual Report of the Rhode Island Department of Public Works* (January 1939), p 132

25. Daniel B. Luten, *Reinforced Concrete Bridges* (Indianapolis: published by the author, 1924)

26. "Six Concrete Patents Void on Broad Grounds," *Engineering News* Vol. 74, No. 23 (December 1915), p. 1094

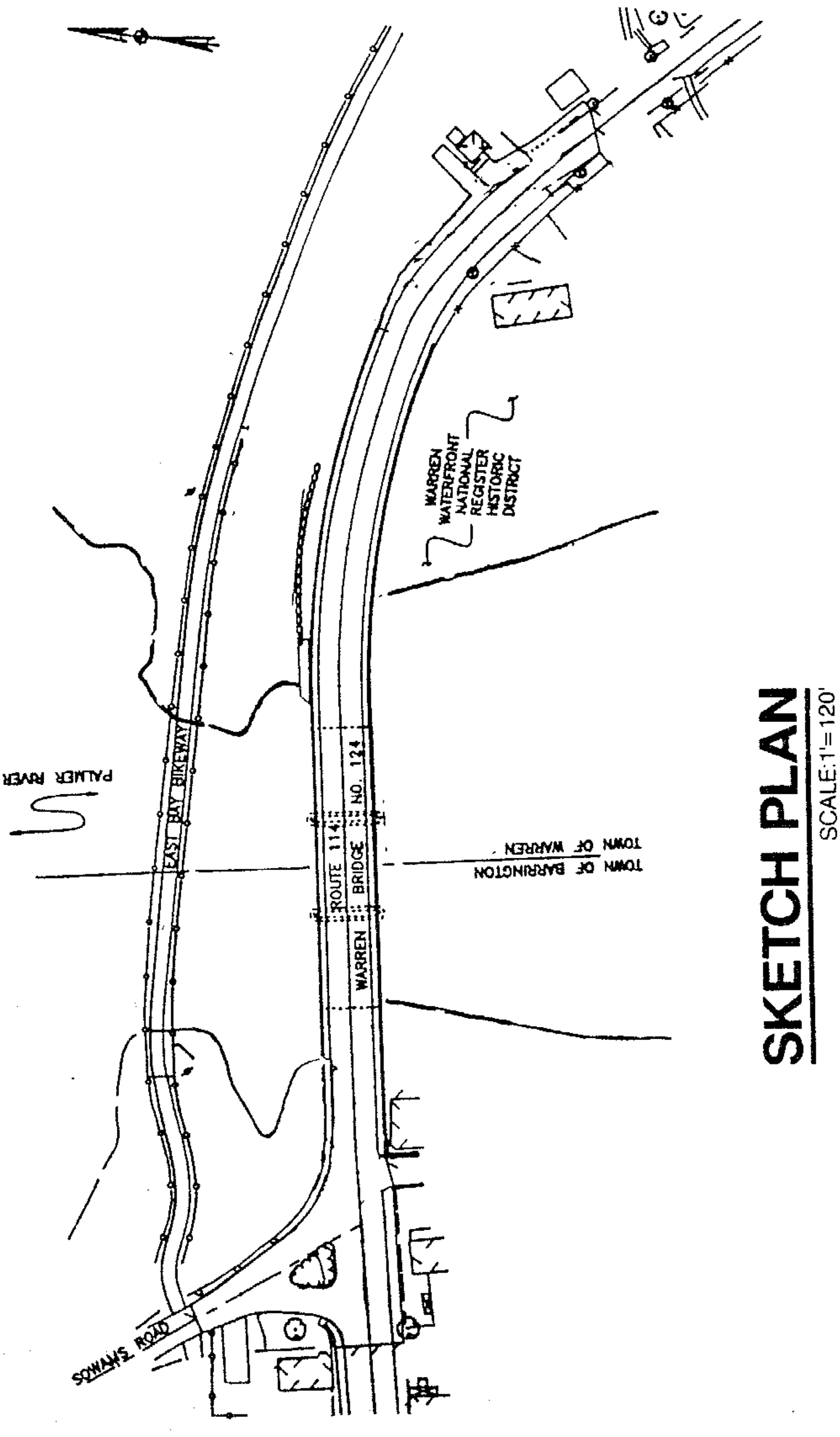
27. Daniel B. Luten, "Patented Concrete Bridges." *Proceedings of the American Society of Contracting Engineers*, (Oct. 1912), p. 359

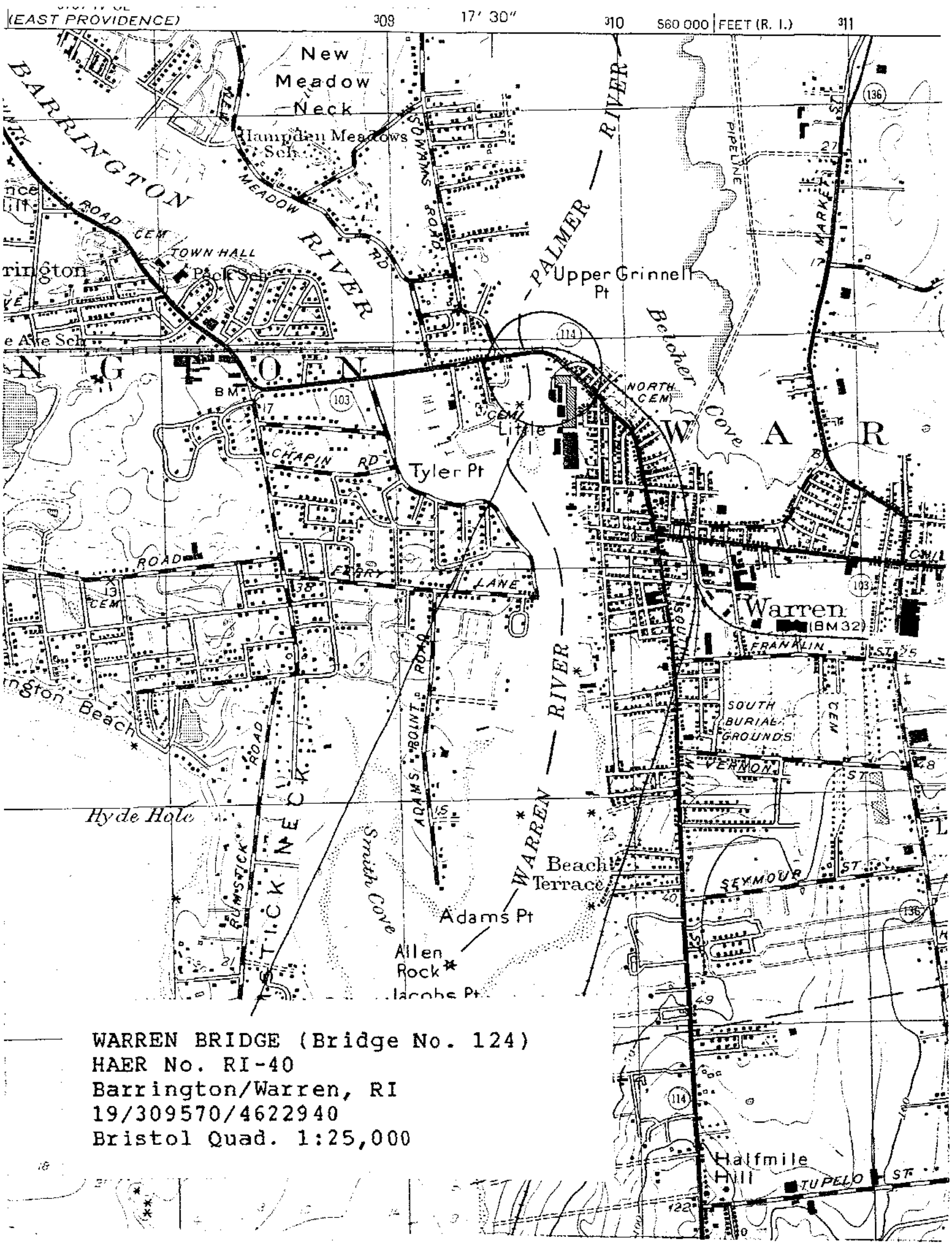
28. Daniel B. Luten, "Concrete Bridges." *Proceedings of the National Association of Concrete Users,* Vol.8, (1912), p. 631

29. These photographs form the main part of a historic bridge collection at the R.I. Department of Transportation (in positive form) and at the R.I. State Archives (in negative form).

30. George Henderson, "Memoir of Clarence Loring Hussey." *Transactions of the American Society of Civil Engineers,* (1926,) p. 1632-33

31. *24th Annual Report of the Rhode Island State Board of Public Roads* (January 1926), p. 98


SKETCH PLAN
SCALE:1'=120'
WARREN WATERFRONT NATIONAL REGISTER HISTORIC DISTRICT
EAST BAY BIKEWAY
ROUTE 114
WARREN BRIDGE NO. 124
PALMER RIVER
TOWN OF WARREN
TOWN OF BARRINGTON
SOWAMS ROAD



WARREN BRIDGE (Bridge No. 124)
HAER No. RI-40
Barrington/Warren, RI
19/309570/4622940
Bristol Quad. 1:25,000